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INVESTIGATION INTO INFLUENCE OF INLET PREWHIRL ON FLOW FIELD OF DIAGONAL IMPELLER WITH EXIT GUIDE VOLUTE

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ABSTRACT

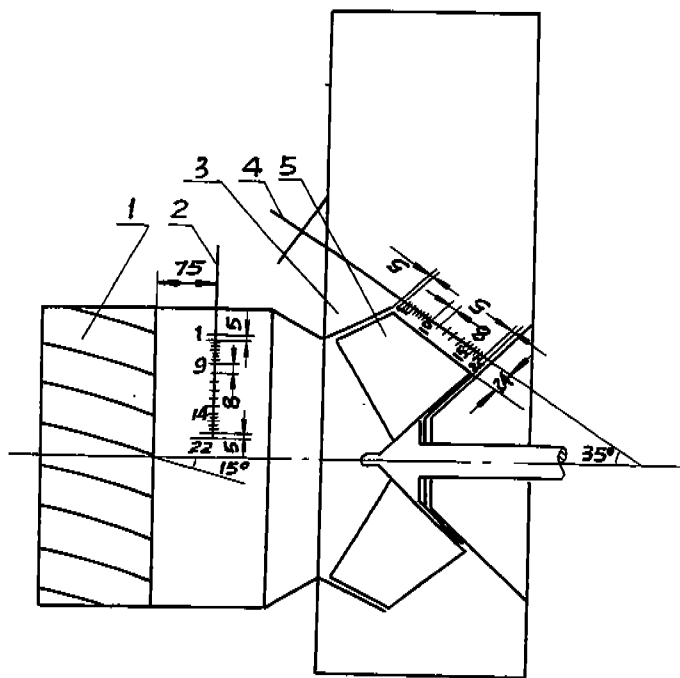
By means of setting inlet pre-rotator, the inlet and exit flow field of the diagonal flow impeller with exit guide volute have been measured with 5 holes probe, in different flow conditions, and in the conditions of positive and negative pre-rotating. The experiment results are compared with that of without the pre-rotator.

1. Introduction

The design method for the matching of diagonal impellers with volutes was introduced in reference [1]. The investigation [2] into inlet and exit flow fields of the diagonal impeller with a exit guide volute was made in the homogeneous inlet flow, in which some of experiment data were collected for studying the internal flow feature of that fans. Considering the mentioned work, we put a pre-rotator on the impeller inlet. The investigation of inlet and exit 3-D even flow field of the diagonal impeller with exit guide volute have been carried out. The influence of the pre-rotator on the flow field has been studied. Which are as follows.

2. Impeller used in experiment and measured point distribution

The experiment has been carried out on a discharge test bed which is accorded with GB1236-85, the National Test Standard of China. The diameter of the wind pipe of test bed is 300 mm. The power of the motor is 7.5 KW. The impeller used in experiment is half open type ,welding blades. The flow type design is free vortex. blades are formed by means of wriggling under the design of quasi 3-D flow theory.



1 - Inlet pre-rotator 2 - Five holes probe(at inlet) 3 - Five holes probe (at exit)
4 - Diagonal impeller 5 - Exit guide volute

Fig.1 Impeller used in experiment and distribution of the measured point

The parameters of the impeller are as follows: the diameter of the exit tip is 400 mm; the tip slant angle of blades is 25° ; the root slant angle of blades is 45° ; the numbers of the blades are 6. There are one positive and one negative pre-rotator, which prewhirl angle is $\pm 15^\circ$. There are 8 circular arc plates in each pre-rotator. The measured points are chosen sparsely in the middle and densely on the boundary. There are 22 measured points at inlet and 22 at exit from tip to root of the blade, along radial direction. The other sizes are shown in Fig.1.

3. Experiment method and data processing

The inlet and exit flow field have been measured with 5 holes probe, which diameter is 4 mm. the speed is 2000 rpm. The distance between the probe axis and the blades exit of the pre-rotator is 75 mm, that of the impeller is 24 mm. The discharge is measured with Pitometr. Conditions of the experimenter as follow: in the design flow factor \bar{Q} ($=0.283$); in small flow $0.83 \bar{Q}$ and large flow $1.15 \bar{Q}$ and in the positive, negative pre-rotator and without pre-rotator. At last, the data measured on the coordinate system of the probe traverse have been transformed into the distribution of 3-D velocities on cylinder coordinate, as follows:

$$\begin{aligned} C_r &= |\vec{C}| \cdot (\cos \delta \cdot \cos \alpha \cdot \cos \beta - \sin \delta \cdot \sin \beta) \\ C_u &= -|\vec{C}| \cdot \cos \delta \cdot \sin \alpha \\ C_z &= |\vec{C}| \cdot (\cos \alpha \cdot \cos \delta \cdot \sin \beta + \sin \alpha \cdot \cos \beta) \end{aligned}$$

where:

- α — the angle between the component on the equator plane of velocity \vec{C} and the meridional plane of the probe.
- δ — the angle between the velocity \vec{C} and the equator plane of probe.
- β — the angle between axis of the probe and the rotating axis of the diagonal impeller.

4. Experiment results and analysis

(1) The velocities distribution on the impeller inlet

The non-dimensional velocities distribution of the axial velocity, C_{z1} , and radial velocity, C_{r1} , and circumferential velocity, C_{u1} at the inlet of the impeller are shown in fig.2, 3 and 4 respectively, in conditions of the design and the positive and negative pre-rotating. It is compared with that in conditions of non-prewhirl. From which, the velocities, C_{z1} , C_{r1} and C_{u1} , in non-prewhirl, are constant approximately, from root to tip of blades (r_t — radius of the blade tip in exit). The axial velocity, C_{z1} , reduce from the root to tip of the blade, in the positive pre-rotating condition. it changes in a small way negative pre-rotating (as shown in Fig.2). The radial velocity, C_{r1} , increases slowly from root to tip of the blade (as shown in Fig.3). That is coincident with the experiment re-

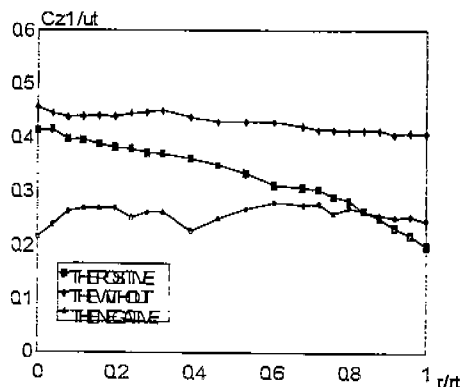


Fig.2 Distribution of the axial velocity

The comparison of the distribution of circumferential velocity, C_{u1} , (as shown in Fig.4) shows that the C_{u1} is equal to zero approximately in the condition of non-prewhirl, and it is equal to a positive value in the positive pre-rotating, and to a negative value in the negative pre-rotating. the C_{u1} in the positive and negative pre-rotating distribute on the side of non-pre-rotating respectively. it proves that the inlet pre-rotating has influence on the distribution of the circumferential velocity C_{u1} .

(2) Distribution of the total pressure loss in the inlet

In this paper, the factor of the total pressure loss is defined as follows :

$$\zeta = \Delta P / \frac{1}{2} \rho C^2$$

where ΔP is the difference of the stagnation pressure between the measured point and the inlet point , ρ is the density of gas in the measured point . The factor of the total pressure loss in three prerotating conditions are shown in Fig.5.

The comparison are shown that the pressure loss in the negative pre-rotating is the largest in the three conditions; the pressure loss in the positive pre-rotating is larger than it in the non-pre-rotating. The change of ζ is larger in the positive pre-rotating than in the negative, along the root to tip of blades. The experiment results have shown that the inlet pre-rotating flow has influence on the pressure losses.

sults in Reference[2].

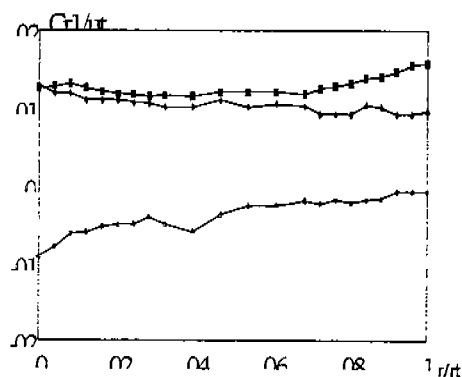


Fig.3 Distribution of the radial velocity

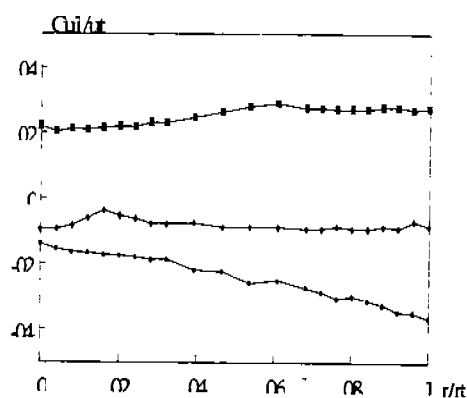


Fig.4 Distribution of the circumferential velocity

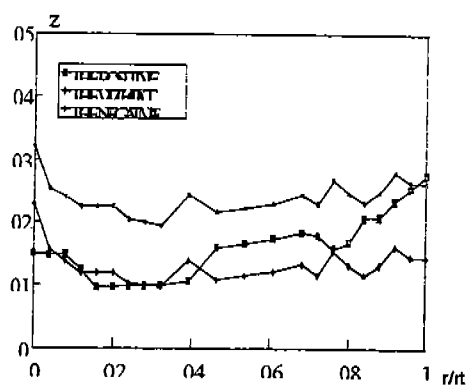


Fig.5 Distribution of the total pressure loss

(3) Distribution of the velocities in the impeller exit

The comparisons of the distribution in the impeller exit are shown in the Fig.6 ,7 and 8. It shows that the values of the axial velocity, C_{z2} , radial velocity, C_{r2} , and circumferential velocity, C_{u2} , in the impeller exit are different from each other a little, in the non-pre-totating. The 3-D feature of the

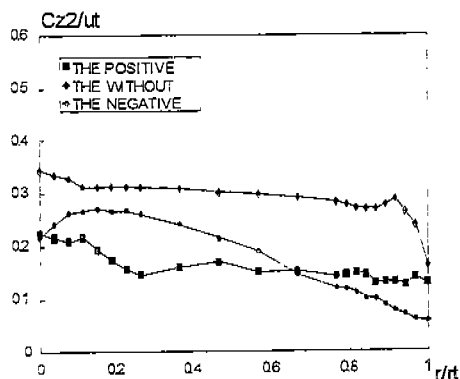


Fig.6 Comparisons of the axial velocity distribution on the impeller exit

flow within the diagonal impeller has been proved and it is similar to the velocities distribution of positive pre-totating. At the same time, the velocity of main flow area between blades is almost constant from root to tip of blades except the end wall boundary, which have show the influence of the end wall boundary effect.

In the condition of negative pre-totating, the velocities, C_{z2} , C_{r2} , and C_{u2} , changes largely from root to tip of blades. Although the negative pre-totating increases the impeller work, the velocity gradient in flow field increase rapidly, which influence the flow field badly.

(4) Meridional velocities distribution with different flow

The meridional velocities, C_{m2} , distribution in the meridian plane exit are shown in Fig.9, 10 and 11 in three conditions of the inlet pre-totating, with different flow. From which, with the flow increasing, C_{m2} , increases also; the distribution of C_{m2} from root to tip of blades decrease gradually; the change of C_{m2} from root to tip of blades is the largest in the negative pre-rotating condition (as shown in Fig. 10); while similar change of the velocity distribution exist in the positive pre-rotating(as shown in Fig. 9) and non-pre-rotating (as

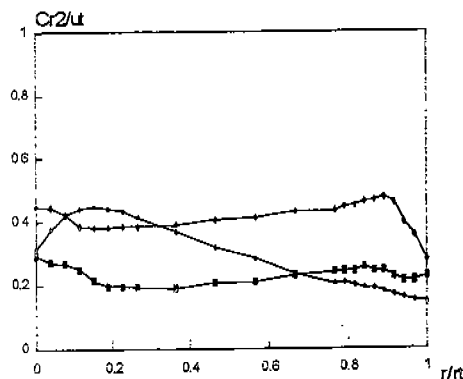


Fig.7 Comparisons of the radial velocity distribution on the impeller exit

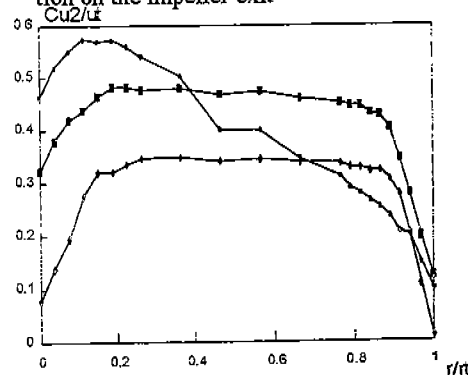


Fig.8 Comparisons of the circumferential distribution velocity on the impeller exit

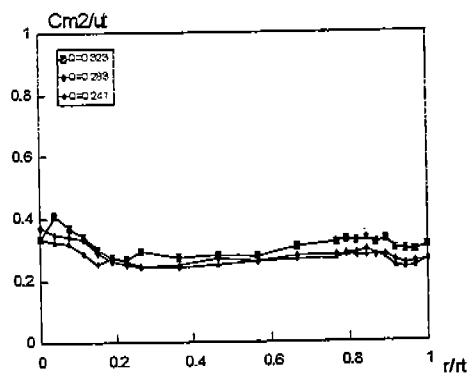


Fig.9 Comparisons of the meridional velocity distribution with different flow(in the positive pre-rotating)

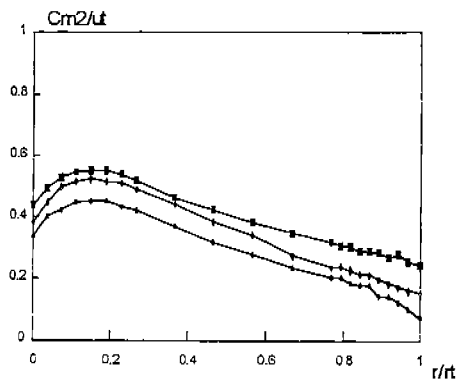


Fig.10 Comparisons of the meridional velocity distribution with different flow(in the negative pre-rotating)

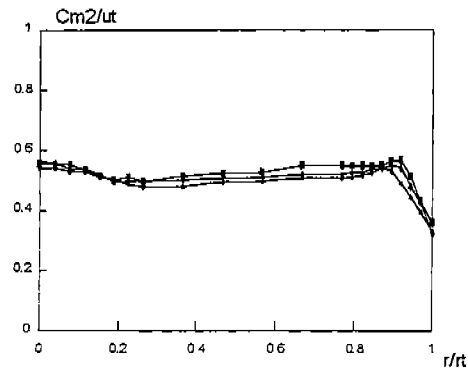


Fig11.comparisons of the meridional velocity distribution with different flow (in the non-pre-rotating.)

shown in Fig. 11).

5. Conclusions

The 3-D inlet and exit flow fields of the diagonal impeller with exit guide volute have been measured with 5 holes probe. The experiment results show that the condition of the negative pre-rotating has influence largest on the losses and the construction of the flow field.

Reference

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